UDC 551.583.15:551.513.7:551.524.35(775)"1843"

THE UNUSUAL GENERAL CIRCULATION PATTERN OF EARLY 1843

HANS E. ROSENDAL

ESSA State Climatologist, Madison, Wis.

ABSTRACT

The year 1843 produced some unusually cold months in the upper Mississippi Valley, with March about 25°F below normal for the largest monthly departure of record in the area. A short summary of the winter months of 1842–43 in Wisconsin is included. A check of climatological data for Europe showed that unusually mild weather prevailed in eastern Europe during January and February 1843, while March 1843 was near normal. The effects of snow and ice cover in maintaining a strong and persistent anomalous flow pattern is alluded to. A high frequency of record coldest and warmest months in Wisconsin occurred during the 1830's and 1840's. High dust content of the upper atmosphere from frequent volcanic activity with reduced incoming solar radiation during the 1830's may be partially responsible for the occurrence of the many cold months.

In areas of large temperature variability, such as the interior of the North American Continent, average daily temperatures occasionally depart from their long-term normals by 25°F or more during the colder half of the year. The occurrence of enough of these unusually warm and cold days consecutively to produce a week with a 25° departure becomes much more rare, especially if the week is arbitrarily determined as the calendar week, Monday through Sunday, as used for example in the *Weekly Weather and Crop Bulletin*. When the mean temperature of a whole calendar month departs from its long-term normal by more than 25°, it is truly a rare event, especially if it occurs outside Montana and the bordering Canadian Prairie Provinces where temperature variability is exceedingly large in winter.

The month of March 1843 was such a month of enormous temperature departures amounting to 25° to 30° below the long-term normals over the upper Mississippi Valley and the Dakotas (figs. 1 and 2). Over areas farther south and east to the Gulf and Atlantic Coasts, temperatures departed by a sizeable 10° to 20°. To the northeast in New England, temperatures were only moderately below normal with above-normal warmth probably found over Newfoundland, Labrador, and the Greenland area. Likewise, we may expect from our knowledge of these departure patterns and the wavelengths of the upper westerly flow that temperature departures must have decreased westward from the cold center over North Dakota with above-normal warmth probable along the Pacific coast.

Meteorological data were surprisingly good in both quality and quantity during these days of a sparsely settled interior in March of 1843, thanks to the observations taken by the Army surgeons at the military posts which dotted the eastern half of the country. Unfortunately, no meteorological observations were taken in the Dakota territory, but data were available from forts along the southern and eastern flanks of the center of the cold air. These forts included Fort Snelling (St. Paul, Minn.), Fort Crawford (Prairie du Chien, Wis.), Fort Winnebago (Portage, Wis.), Fort Croghan (near Omaha, Nebr.), and Fort Leavenworth, Kans. (see Lawson 1851, 1855).

What certainly must have been one of the longest drawn-out winters of record occurred during the 1842–43 season in the upper Midwest. At Fort Snelling near St. Paul during November 1842, the monthly mean temperature was 7° below normal at 25°F and with precipitation very heavy for November at 3 to 4 in. extending across much of Wisconsin, Minnesota, and Iowa. The month was characterized by several crossings of the Midwest of deep low-pressure systems originating in the Southern Plains States and bringing heavy moisture northward from the Gulf. The storm of November 8–10 alone dropped 12 to 18 in. of snow over large areas of Illinois, Iowa, Minnesota, and Wisconsin, with 24 to 36 in. reported around Fort Winnebago. Severe cold waves occurred behind these Lows on November 16–18 and 28–30, with the Erie Canal and the Ohio and upper Mississippi Rivers closed to navigation during the latter part of the month. Another low-pressure system on December 3–5 dropped additional heavy snow in the upper Mississippi Valley. Up to 3 ft of snow fell in central Wisconsin, with a total of 6 ft on the ground after the storm (Clak 1881). From that time on until spring, travel by teams was suspended. Lapham (1846) in commenting on conditions in Wisconsin observed that "the winter of 1842–43 was distinguished by the unusual quantity of snow and the great length of time it remained on the ground. Sleighing commenced about the 10th of November and continued until the same time in April, being five months."

Following the cold and snowy November of 1842, December had near-normal temperatures, while January 1843 was on the mild side, thanks to a thaw lasting from about the 10th of January through the 29th. The heavy snow cover in the upper Mississippi Valley survived the foggy and drizzly weather of the thaw, as maximum temperatures at Fort Snelling and Fort Crawford never rose out of the low 40's during the month. In extreme southeastern Wisconsin and points farther south and east, temperatures rose into the 50's and 60's on several days, and occasional rains helped deplete most of the snow cover by late January. On the last day of January, severe winter weather returned with a vengeance, and along with the cold came heavy snows that spread a deep mantle south-

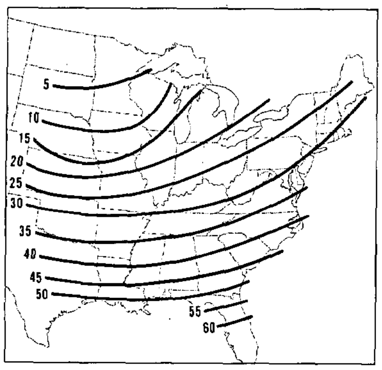

FIGURE 1.—Monthly mean temperature (°F) for March 1843.

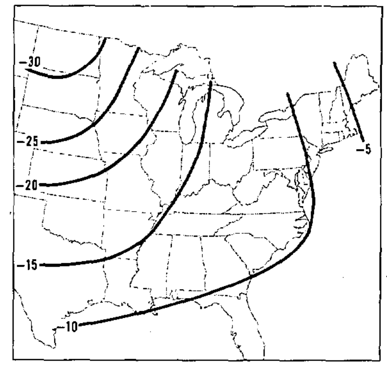

FIGURE 2.—Temperature departure (°F) from recent 30-yr normal, March 1843.

ward to near the Gulf of Mexico and eastward to the Atlantic. At Whitewater in southeastern Wisconsin, the new snow cover soon reached a depth of 4 to 5 ft (Cravath 1906).

February turned out to be a bitterly cold month with an average temperature of 2°F for the State of Wisconsin (Rosendal 1970). This is the coldest February of record in the State and only 4° warmer than the coldest month of record, January 1912. A deep and extensive snow cover thus existed over much of the eastern two-thirds of the country at the end of February 1843; and the Great Lakes, in all probability, were almost completely covered with ice. This situation set the stage for producing still another month of severe winter weather during March 1843, much like the one that occurred recently during March 1960 on a smaller scale. The trough aloft remained firmly anchored over the snow and ice fields of the Midwest during a month when we normally expect maximum mobility of the troughs and ridges of the middle troposphere. The combined effects of the high albedo of the snow-covered plains, the ice-covered Great Lakes, and the snow- and cloud-covered darker forested areas farther south and east, together with the good radiating and heat-insulating properties of the snow cover, all combined to cool the atmosphere above the snow fields and helped maintain the trough aloft. In contrast, strong warming must have taken place over the nearly cloudless mountains of the west under the ridge aloft during this period of strongly increasing solar radiation.

The precipitation for the month of March 1843 (fig. 3) bears out this anomalous flow pattern with the center of circulation low aloft pulled far south of its normal position over the Canadian Arctic. Precipitation was light and all falling as snow over northern areas. Amounts increased rapidly southward and eastward toward the Gulf and Atlantic Coasts, approaching the mean position of the jet stream and the storm tracks following along the cold snow-covered continent's border with the warm oceanic areas. The coldness of the upper air trough is borne out by the very heavy snows experienced across the Gulf States, in the Ohio and lower Mississippi Valleys, and up along the Atlantic coast during the latter half of March 1843 (Ludlum 1968). These snows were deposited by the storms of March 15–16, 21, and 24–25.

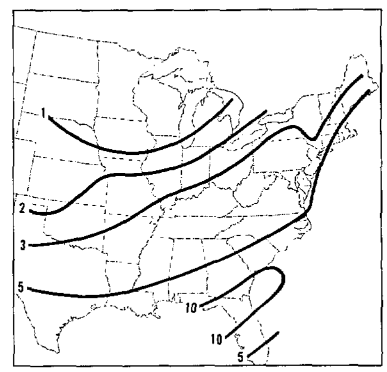

FIGURE 3.—Total precipitation in inches for March 1843.

The upper Mississippi Valley, far north of the active storm tracks during February and March of 1843, experienced a steady cold with no sharp gyrations of the mercury. At Fort Snelling, the absolute minimum temperatures were −23°F and −20°F for these 2 mo, respectively, which are not unusually cold extremes for these months. Absolute maximum temperatures of 30°F during February 1843 and of only 27°F in March 1843, on the other hand, clearly show the persistence of this late winter cold. The mercury never reached above the freezing mark at Fort Snelling during the 60-day period, Jan. 30–Apr. 1, 1843.

Spring eventually arrived across the Midwest during April. The snow cover melted fairly rapidly, and fields began to turn green in the Ohio Valley by midmonth. There was no frost in the ground in the upper Mississippi Valley where snow cover had been continuous since early November, and the relatively dry soils from a series of low precipitation years since 1837 were able to absorb the snow-melt water with no flood resulting (Clak 1881). Crops and pastures had been well protected, though some winterkill occurred in Illinois, Indiana, Ohio, and Michigan, where the snow cover was temporarily removed by the January thaw (Schorger 1968). Feed supplies were completely exhausted in most areas, and cattle and hogs starved by the thousands. Fuel supplies, likewise, were at a very low level throughout the Midwest and the Plains States. Needless to say, the navigation season was very late in getting underway, with many vessels frozen

378-480 O - 70 - 2

in since the latter part of November, away from their home ports on the lakes and all the way up the Mississippi. At Muscatine, Iowa, the river was closed for a record 133 days. On the Great Lakes, the port of Milwaukee was not declared free of ice until April 14, and the Erie Canal had its latest and only May opening on May 1. The following quote from *The Milwaukee Sentinel* (1843) sums up the feeling of frustration along the frontier: "Never within the recollection of the oldest inhabitants of Wisconsin has there been so much snow as at the present time. In the country, the cattle are suffering for the want of food and shelter. . . . On the 26th of March, last year, the steamboat *Chesapeake* arrived here from the Lower Lakes. This year it is doubtful whether one will be here by the 26th of May."

The winter of 1842–43 has been unequaled in its length in most areas of the interior United States east of the Rocky Mountains. The sequence of events in the upper Mississippi Valley is illustrated by the monthly mean temperature data at Fort Snelling as compared with the recent 30-yr normals appearing in table 1.

The early settlers experienced a sudden, severe beginning of winter after the heavy snows of early November. Temperatures did not change much over the next 2 mo, as a normal December merged into a mild January with some thawing during the latter half of the month. A sharp turn to very cold weather occurred on January 31, with February and March being almost equally cold.

In the preceding paragraphs, the author has tried to relate low March temperatures in midcontinental areas to an unusually extensive and deep snow cover. The answers are, of course, not always so simple; large snow areas often disappear in midwinter over a relatively short span of time. The ridge and trough positions over the North American sector presumably are affected by conditions over the neighboring oceans and over the vast Eurasian Continent, as well as by effects from the Southern Hemisphere. Sudden changes in the ridge and trough positions may also be caused by adjustments in the upper flow pattern as wavelengths increase and the number of pairs of ridges and troughs around the Northern Hemisphere decreases seasonally with the strengthening of the north-south temperature gradient and the westerly flow aloft during winter.

The month of March has relatively large temperature variability in the Midwest and the Ohio Valley (Thom 1968), perhaps due to the high variability in the extent of snow cover over North America during this month of sharply increasing incoming solar radiation. Observational data will verify that the assumption of monthly mean temperatures being normally distributed about their long-term normals holds fairly well in spite of the inherent persistence of such data operating over periods of months and longer due to feedback mechanisms between the general circulation and heat sources or sinks of the underlying earth's surface. Large-scale differences along a latitude circle in snow and ice coverage, soil moisture, and sea-surface temperatures are examples of surface properties that will affect the flow pattern for some distance aloft due to the heat, moisture, and radiation balances. The March 1843 departures of 25° to 30° below normal in the

TABLE 1.—*Monthly mean temperatures, November 1842–April 1843, at Fort Snelling, Minn., compared with the 1931–60 Minneapolis normals*

Month	Mean (1842–43) (°F)	Normal (1931–60) (°F)	Departure from normal (°F)
Nov.	24.6	31.2	− 6.6
Dec.	18.0	18.1	− 0.1
Jan.	20.7	12.4	+ 8.3
Feb.	2.0	15.7	−13.7
Mar.	4.7	27.4	−22.7
Apr.	43.6	44.3	− 0.7

upper Mississippi Valley and North Dakota amount to more than four standard deviations and are the largest departures in this area for all months since records started around 1820. The gradients and curvatures of the isotherm and departure maps suggest departures of about 30° in North Dakota where no data are available.

A listing by rank of the 5 warmest and 5 coldest months of March in the past 150 yr for Madison, Wis. (Miller 1927), together with the long-term normal and standard deviation are shown in table 2 for comparative purposes. Some of the data from the earlier years have been estimated from nearby stations.

The March 1843 mean temperature at Madison (13.0°F) more than 9° lower than the next coldest March, stands out conspicuously. A check with temperature data for St. Louis (25.3°F), St. Paul (4.7°F), Fort Leavenworth (17.5°F), and Fort Croghan (12.9°F) near Omaha tells a similar story of unusually large departures from normal.

The month of March 1843 was very much an extreme case in the amount of departure from normal. The 1830's and 1840's had more than their share of extremely cold months in the upper Midwest, and a few very warm months also. In a listing in table 3 of monthly mean temperatures for Wisconsin covering 150 yr, the extreme coldest or warmest months of record for the State are listed if they occurred during these two decades.

Thus, we find eight cases in which the individual monthly means were the coldest of record and four cases where they were the warmest, for a total of 12 cases out of a possible 24. In other words, if we ignore the February, August, and November ties with years outside the period, half of all these extremes of monthly means in Wisconsin occurred during the two successive decades 1830–49, which comprise only about 13 percent of the length of the period of record. It is difficult to see how chance or instrumental and procedural errors could combine to produce this high frequency of extremes.

Unusually cold years in the past have been caused by less solar energy reaching the earth's surface due to dustiness of the atmosphere in periods of high volcanic activity. The occurrence of the 4 extreme cold months of June 1842 and February, March, and October 1843 within a time span of 2 yr in Wisconsin suggests that perhaps these were unusually dusty years. Volcanic activity was at a very high level during the decade of the 1830's, according to Lamb and Johnson (1959), while the 1840's were void of major eruptions according to these authors' volcanic

TABLE 2.—*Listing by rank of the 5 warmest and 5 coldest months of March during the period 1820–1969 at Madison, Wis., and the departure from the 150-yr normal (31.4° and standard deviation 5.0°F)*

	March	Temperature	Departure
5 warmest months	1945	45.2°	+13.8°
	1910	44.6	+13.2
	1878	43.9	+12.5
	1946	42.3	+10.9
	1842	41.4	+10.0
5 coldest months	1856	23.0	− 8.4
	1899	22.6	− 8.8
	1888	22.5	− 8.9
	1960	22.3	− 9.1
	1843	13.0	−18.4

TABLE 3.—*Extreme warmest and coldest months of the period 1820–1969 in Wisconsin that occurred during the two decades of the 1830's and 1840's*

Month	Year	Mean		Normal	Departure
Jan.	1846	29°F	warmest	14	+15
Feb.	1843, 1875	2	coldest	16	−14
Mar.	1843	10	coldest	29	−19
Apr.	1839	54	warmest	43	+11
June	1842	54	coldest	64	−10
July	1830	76	warmest	69	+7
Aug.	1836, 1849, 1915	62	coldest	67	−5
Sept.	1831, 1835	52	coldest	60	−8
Oct.	1843	36	coldest	48	−12
Nov.	1830, 1845	42	warmest	34	+8
Nov.	1838, 1880	23	coldest	34	−11
Dec.	1831	3	coldest	20	−17
Year	1843	38.1	coldest	43.6	− 5.5

activity index. The possibility, nevertheless, exists that major eruptions went unreported in remote areas of the world during this period. Much of this activity of the 1830's seems concentrated in the year 1831, when, according to Abbot and Fowle (1913), there occurred "three moderate eruptions and three more of the very first magnitude," and dust was very widespread in the atmosphere around the world. The very low temperatures of September and December of 1831 in the upper Mississippi Valley can possibly be partially explained to this phenomenon. Volcanic eruptions again occurred in 1835 in Nicaragua and in 1837 on Kamchatka (Humphreys 1929). Dust introduced into the stratosphere by volcanic activity is thought to settle into the troposphere and rain out over a time span of 2 to 4 yr.

The answer to the question of what type of general circulation pattern could have produced so many extremes in Wisconsin must be found in a Northern Hemisphere upper air flow of large amplitude or "blocking" proportions with relatively large temperature differences between troughs and ridges during these two decades. Frequent stalling of the progressive movement of troughs and ridges aloft must have occurred over favored locations. Extreme cases of such sluggishness or stagnation of the upper flow pattern across North America recurred during the middle and late 1870's. The cold and snowy winter period, January–April 1875, when temperatures in the upper Mississippi Valley averaged 11° below normal over this 120-day period, is such an example. An even more extreme case was the nearly snowless winter of December 1877–April 1878 in this same section of the country when temperatures averaged 14° above normal over a 150-day period (U.S.Weather Bureau 1911).

Unusually large temperature departures during winter months often occur simultaneously on both sides of the Atlantic at times of strong high-latitude blocking. The recent case of January 1963 is a good example of such blocking, with very low temperatures in both the United States and Europe. According to Blodget (1857), "the low temperatures of February and March 1843, which rendered the mean of that year below the average, was unknown in Central Europe." March 1843 in Europe was close to normal in most respects, but further investigation of monthly climatic data, as published by the U.S. Weather Bureau (1959, 1965) and the Smithsonian Institution (1927, 1934, 1947), showed that the preceding months of January and February did exhibit some unusual characteristics, with signs of stagnation and blocking in the flow of the upper westerlies across Europe.

January 1843 in central Europe, according to a daily series of weather observations from Breslau in Silesia (Galle 1857), consisted of a mixture of a few cold days early in the month and again during the period of the 19th to the 25th which were more than counterbalanced by mild days, particularly during the last week of the month. As a result, January temperatures were slightly above normal in most of western and central Europe, but much above normal over eastern Europe. The two easternmost stations for which monthly mean temperature data were available, Helsinki and Wilno, both had monthly mean temperatures of 30°F, about 9°F above normal. A measure of the strong poleward shunting of the westerlies across northwestern Europe upstream from the blocking area during January was the record (150 yr) 5-in. precipitation received for the month at Copenhagen. Not much additional information was at hand outside Europe, except for January 1843 precipitation at two stations in India, Madras and Cochin, which both had extremely large totals for the normally very dry northeast monsoon, 6.50 and 5.15 in., respectively. Perhaps this is a reflection of an unorthodox behavior of the westerlies across central Asia.

Further investigation showed that February 1843 brought extreme temperatures to Europe, much as in North America. The longitude line of 10° E. roughly separated below-normal temperature areas to the west from above-normal areas to the east. Departures above normal increased eastward from −4°F at London and Edinburgh, −2°F at Amsterdam, +2°F at Frankfurt A/M, +4°F at Berlin, +9°F at Breslau, and +11°F at Vienna to +12°F at Budapest and Wilno. Vienna at 42.4°F, Budapest at 44.4°F, and Wilno at 35.6°F, all with nearly 200-yr periods of record, experienced their warmest February of record. To the north, Copenhagen, near the dividing line between the above- and below-normal areas, had a positive departure of 0.5°F, while Helsinki farther east was 6°F above normal. To the south, Rome was 1°F above normal. Maximum positive departures again seemed to be located in Russia, though probably farther south than in January in the Black Sea region. Vast portions of Russia and eastern Europe most likely were without snow cover much of this winter.

The relatively few precipitation values available for February 1843 indicate generally light values except for the Mediterranean Basin where data for two stations, Rome and Milan with 7- and 9-in. totals, respectively, were available. A high frequency of foggy and cloudy weather prevailed north of the Alps, according to the Breslau record. At Breslau, there were 14 days with fog against a normal of 4; 7 days with rain against a normal of 4; and 2 days with snow against a normal of 6. Precipitation for the month was slightly below normal. A check of the Indian stations showed a return to normally light amounts in this area.

Surface wind measurements, again at Breslau, show high frequencies of winds from easterly directions during February 1843. Winds from these directions normally would indicate a cold winter month with crisp, clear weather in Europe. However, a comparison with wind data from other nearby stations indicate that wind directions within the Silesian area are quite strongly influenced by local topography. Breslau is located in the wide Oder River Valley with the Sudeten Mountains rising abruptly to the southwest. These topographical effects on wind data are accentuated by the fact that hours of observation were at 6 a.m., 2 p.m. and 10 p.m., which means that in many cases winds were observed under strong inversion conditions during a winter month. Wind data from a total of seven stations in Silesia do show resultant directions between southeast and southwest for February 1843.

Average monthly surface pressures for the European stations were well below normal. This, together with warm moist southerly winds in central Europe in February, indicates that a deep trough or low center aloft was quasi-stationary over the continent and the Mediterranean, with heavy precipitation over the Mediterranean Basin and on the south slopes of the Alps and their eastward extension. Daily mean temperatures at Breslau, deep in the continent, were more reminiscent of those of a station in Ireland, with temperatures remaining above freezing from Jan. 27 through Mar. 1, 1843, except for slightly below on 2 days. The mean temperature for February 1843 in Breslau was 38.5°F, with a low of 28°F and a high of 56°F.

The persistent and nearly stationary large-amplitude flow pattern, which dominated the weather in Europe and North America with unusual warmth and cold in the respective areas during February 1843, broke down to a more variable pattern in the European sector in early March. Across North America, this anomalously strong flow pattern remained so entrenched that it was not until a month later in early April that a more springlike pattern could establish itself.

There are indications that the climate of the world during the last decade or two has reassumed many of the characteristics of the first half of the 19th century (Wahl 1968). It is, therefore, important for the meteorologist to become familiar with the behavior of the atmosphere during these years, and for agriculture and temperature-sensitive industries (such as natural gas and fuel oil distribution and storage companies, electric utilities, and river and lake navigation interests) to plan accordingly so as to be able to operate efficiently under the severe winter conditions more prevalent in the early part of the 19th century. Attempts to reconstruct and explain the atmospheric circulation on a global scale during the 1830's and 1840's may prove fruitful to the climatologist. The author did not search very deeply into the wealth of additional instrumental as well as noninstrumental data certainly available around the world for these years.

REFERENCES

Abbot, C. G., and Fowle, F. E., "Volcanoes and Climate," *Smithsonian Miscellaneous Collections*, Vol. 60, No. 29, Washington, D.C., Mar. **1913**, 24 pp., (see p. 1).

Blodget, Lorin, *Climatology of the United States*, J. B. Lippincott and Co., Philadelphia, Pa., **1857**, 536 pp., (see p. 316).

Clak, Sat, "Sat Clak on the Weather," *The Janesville Daily Gazette*, Wis., Mar. 29, 1881, p. 1.

Cravath, P., *Early Annals of Whitewater*, Wis., **1906**, p. 61.

Galle, Johann G., *Grundzüge Der Schlesischen Klimatologie*, (Fundamentals of the Climate of Silesia), J. Max and Komp, Breslau, **1857**, 127 pp.

Humphreys, W. J., *Physics of the Air*, 2d edition, McGraw-Hill Book Co., Inc., New York, **1929**, 654 pp.

Lamb, H. H., and Johnson, A. I., "Climatic Variation and Observed Changes in the General Circulation," *Geografiska Annaler*, No. 2/3, Stockholm, **1959**, pp. 94–134.

Lapham, Increase A., *Wisconsin: Its Geography and Topography*, Milwaukee, **1846**, 208 pp., (see p. 75).

Lawson, Thomas, *Army Meteorological Register for Twelve Years, 1831–1842*, C. Alexander, Printer, Washington, D.C., **1851**, 324 pp.

Lawson, Thomas, *Army Meteorological Register for Twelve Years, 1831–1842*, C. Alexander, Printer, Washington, D.C., 1851, **1855**, 763 pp.

Ludlum, David M., *Early American Winters II 1821–1870*, American Meteorological Society, Boston, **1968**, 257 pp.

Miller, Eric R., "A Century of Temperatures in Wisconsin," *Transactions of the Wisconsin Academy of Science, Arts, and Letters*, Vol. 23, Madison, **1927**, pp. 165–177.

Rosendal, Hans E., "Wisconsin Monthly and Annual Mean Temperatures and Precipitation Totals, 1820–Present," ESSA State Climatologist, Madison, Wis., **1970**, (unpublished data).

Schorger, Arlie W., Wildlife Ecology, The University of Wisconsin, Madison, **1969**, (personal communication).

Smithsonian Institution, "World Weather Records," *Smithsonian Miscellaneous Collections*, Vols. 79, 90, and 105, Washington, D.C., **1927**, **1934**, **1947**.

The Milwaukee Sentinel, "Weather Note," Wis., Mar. 29, **1843**, p. 1.

Thom, H. C. S., "Standard Deviation of Monthly Average Temperature," *Environmental Data Service Technical Report* EDS-3, ESSA, U.S. Department of Commerce, Washington, D.C., **1968**, 10 pp.

U.S. Weather Bureau, "Temperature Departures, Monthly and Annual, in the United States, January, 1873, to June, 1909," *Bulletin U*, Washington, D.C., **1911**, 5 pp. plus 584 charts.

U.S. Weather Bureau, *World Weather Records, 1941–50* and *World Weather Records, 1951–60*, Washington, D.C., **1959**, **1965**.

Wahl, E. W., "A Comparison of the Climate of the Eastern United States During the 1830's With the Current Normals," *Monthly Weather Review*, Vol. 96, No. 2, Feb. **1968**, pp. 73–82.

[Received July 28, 1969; revised October 30, 1969]